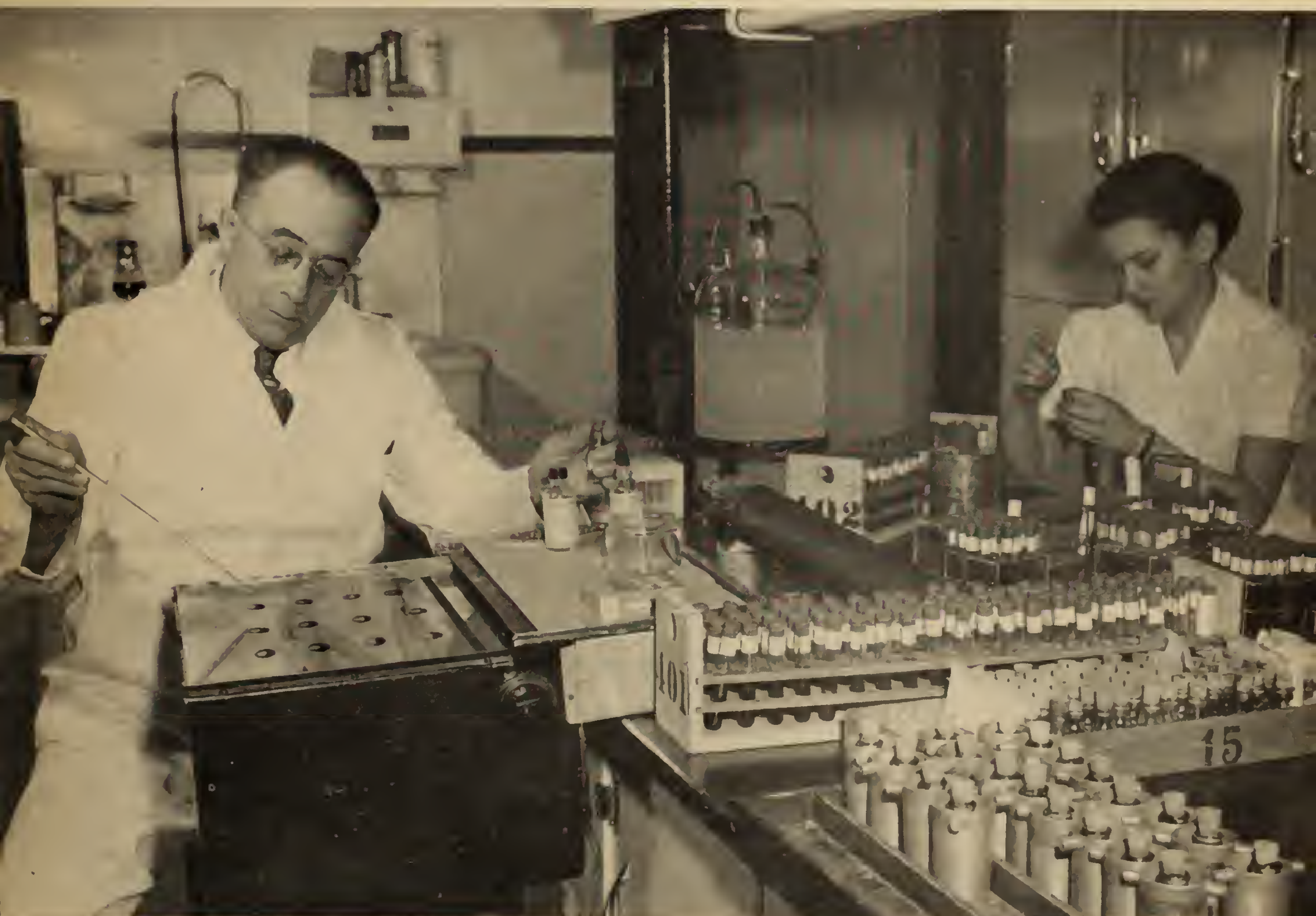
Research FOR FARMERS

SPRING — 1958



CANADA DEPARTMENT OF AGRICULTURE

Research FOR FARMERS

CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. DOUGLAS S. HARKNESS — *Minister*
J. G. TAGGART, C.B.E. — *Deputy Minister*

NOTES AND COMMENTS

In the fruit and vegetable processing industry, an important step in the operation is that of blanching, a heat treatment designed to fix color, inactivate enzymes, and soften the product to facilitate packing. Traditionally, blanching has been done by means of hot water or steam baths but recent tests indicate that these may be supplanted by the use of infra red radiation, an entirely new method of considerable promise. Preliminary experiments by the Horticulture Division in co-operation with a commercial processor have given promising results where the product was moved on an endless stainless steel belt beneath a bank of infra red lamps. The trials involved potatoes, carrots and celery. The celery was most successful in the initial trials and blanching was complete within two minutes where the distance between the product and the heat source was three inches. This development is being watched with interest.

* * *

The history of livestock disease in Canada provides an eloquent testimony to the effectiveness of the control policies of the government. Bovine tuberculosis, once widespread, is now rare. Brucellosis is under concentrated attack and should soon be reduced to negligible proportions. Occasional outbreaks of rabies, hog cholera and other diseases make the news because of their infrequency and other ailments formerly common are now practically forgotten. While this is a gratifying situation it has not come about by chance. Sound control policies have been linked with intensive research. The work carried on in the Department's Animal Pathology Laboratories continues to shed new light on the nature and cause of these diseases and points the way to effective control measures.

Dr. Boulanger's article on the opposite page deals with one aspect of the current research program.

* * *

The introduction of hybrid types has revolutionized the growing of grain corn. At the same time production of hybrid seed has imposed a considerable burden on the seed growers, necessitating the laborious and costly work of detasselling. There now seems to be a real possibility of eliminating this chore. Research men are using a combination of male-sterile inbreds in the single-cross seed parent, with either one or both inbreds of the single-cross pollen parent carrying a 'restorer' gene that has the ability to restore pollen production to the resulting hybrid. The Forage Crops Division already has produced several hybrids by this method. These are now undergoing test trials and satisfactory performance will warrant their release for commercial production.

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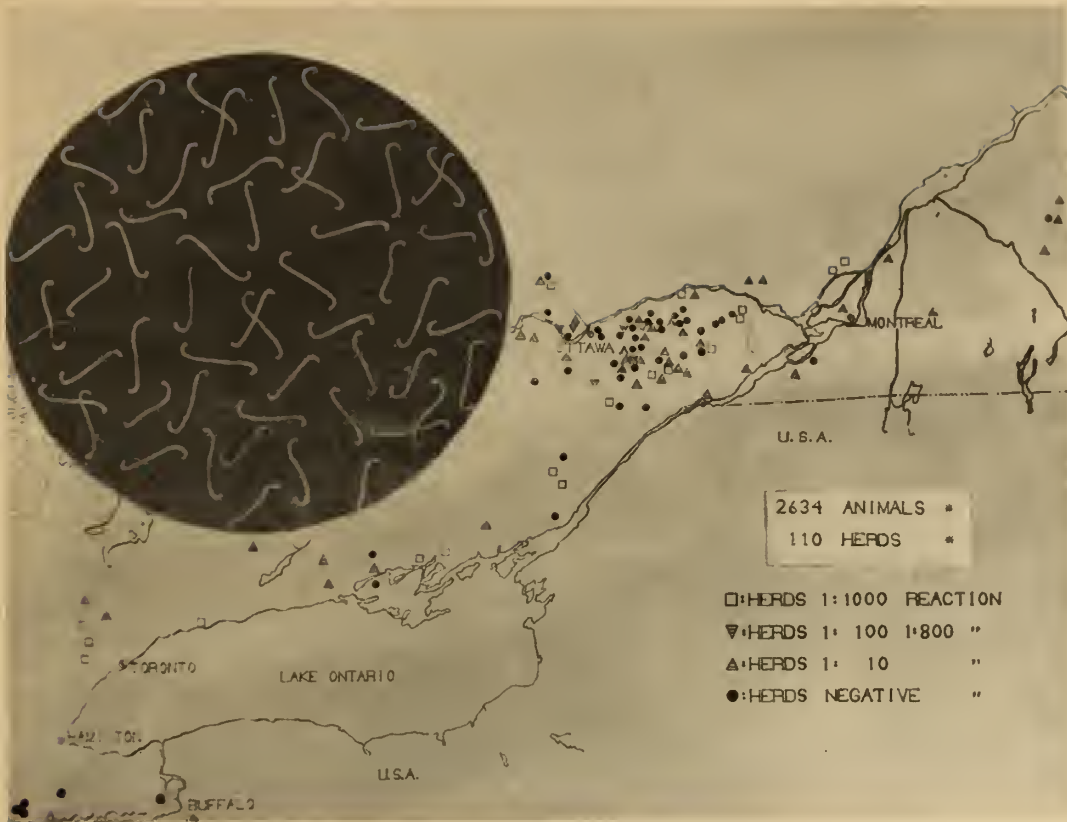
Cover Photo—Blood test being made at the Animal Diseases Research Institute, Hull, Que., to detect brucellosis. Also see opposite page for story on 'leptospirosis' — another disease studied at the A.D.R. Institute.



Inset: **Artist's sketch of *Leptospira pomona* as seen with dark-field microscope. Map shows location of 110 herds tested along with their serological status. Three herds including 61 animals are not shown.**

LEPTOSPIROSIS in CATTLE

Animal Diseases Research Institute Makes Serological Survey and Studies Diseased Herds

LEPTOSPIROSIS, a disease of cattle newly recognized in North America, seems to play an important role in reproductive disturbances. For the past 25 years, attention has been focused on brucellosis as the main cause of such disorders in cattle. As the campaign for brucellosis eradication progressed, it became apparent that considerable abortion still continued in herds where brucellosis could not be implicated. It was not until 1948, however, that the leptospira was isolated and identified as the cause of this disorder in North American cattle. No doubt leptospirosis had been present in the United States and Canada for many years before it was recognized; serological surveys indicate that it is now widespread in both countries. The Animal Diseases Research Institute, Hull, Que., has been studying the disease since 1956.

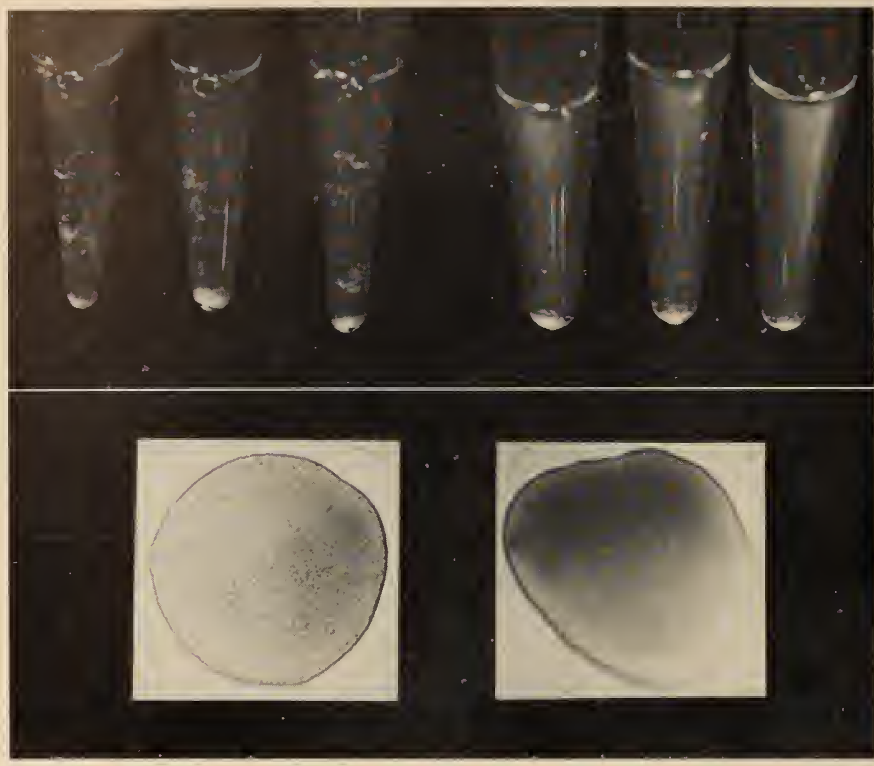
** The author is an Animal Pathologist with the Health of Animals Division serving with the Department's Animal Diseases Research Institute, Hull, Que.*

Paul Boulanger

Symptoms are Diverse

A most variable disease in cattle, the effects of leptospirosis range from a mild almost nonapparent infection to death. Leptospirosis, however, is not confined to cattle and was originally described as Weil's disease in humans in 1915. Later it was recognized in dogs and more recently in horses, sheep, and swine. Field mice and rats often become chronic carriers.

In cattle, the severity of the disease may differ from one herd to another or from one animal to the next in the same herd. In the mild form, only one or two infected cattle in a herd may show high temperature, depression, loss of appetite, labored respiration, a drop in milk yield, or abortion. Blood in the urine is a symptom which may be noticed early or when the cow is recovering. Often bloody urine and a high temperature are the only two main symptoms which the owner will see. Frequently abortion occurs where no symptoms have previously been observed in the herd. In the severe form, the same symptoms are present but they develop in many animals in the herd at intervals of a few days. Temperatures of animals may rise as high as 107°F and death may follow among



Upper: **Typical positive (first 3 from left) and negative *tube* agglutination tests.**
Lower: **Typical positive (left) and negative *plate* agglutination tests.**

mature and young animals alike. With animals that recover, return to normal milk production is slow and the growth of young stock may be retarded considerably.

Disease Hard to Diagnose

The clinical diagnosis of leptospirosis is difficult because most of the symptoms described can be duplicated by other infections. When abortion takes place, suspect leptospirosis if the placental membranes show a yellowish white, blood-free appearance. If brucellosis is the cause, the placenta has a brownish cooked appearance.

Laboratory diagnosis is made serologically by testing the blood serum of cattle for the presence of antibodies produced during the infection. The agglutination-lysis test is the one most widely used and probably the most sensitive; live cultures of leptospiras are dissolved when incubated with serum containing antibodies. Serum from cattle showing acute clinical infection usually reacts in a dilution of 1:10,000 or higher. However, cattle with mild symptoms or with subclinical infection may develop just as marked serological reactivity. Plate and tube agglutination tests are less sensitive than the agglutination-lysis test but they are simpler and easier for a small laboratory to use. A positive result in the serological test is usually accepted as a sign of leptospirosis. Definite proof is obtained by isolating the causative organism by direct cultural methods, or indirectly, by inoculating guinea pigs with suspected material, then culturing their blood at the height of fever.

Certain peculiarities of the leptospira as an organism and of leptospirosis as a disease account for the fact that the infection in cattle escaped attention for such a long time. In the first place the organisms do not grow in the bacteriological media used routinely for diagnostic purposes; a special medium is needed. Furthermore, bacterial contaminants will prevent their growth, making their isolation from tissue or urine very difficult. Finally, leptospiras cannot be stained by ordinary bacteriological methods; the investigator must use the dark-field microscope, a piece of equipment seldom employed routinely in a bacteriological laboratory. In the dark-field, leptospiras appear as motile structures hook-shaped at both ends. Because they live only a short time outside the animal body, the organisms are usually dead by the time specimens of urine or tissue arrive at the laboratory.

Serological Survey Made

A preliminary serological survey, made by the Animal Diseases Research Institute, Hull, Quebec, in 1956 indicated that leptospiral infection was present or had been present in many herds of cattle from Ontario and Quebec; 218 reactors were detected among a total of 2,695 cattle tested and were distributed among 68 of 113 herds sampled. Among the 218 reactors only 36 animals from 21 herds gave strong reactions suggesting fairly recent infection. This proportion of serologically-reactive animals, 8.1 per cent, and the number of herds involved, would suggest a fairly wide distribution of leptospirosis in these provinces. It is much higher than one would have expected from the clinical reports alone and implies that many of these leptospiral infections must have been subclinical. Obviously to evaluate the true economic importance of the disease, further studies were needed to compare serological and clinical findings in herds with reproductive difficulties. Accordingly a total of 20 such herds were studied in 1956, and leptospirosis diagnosed in six of them.

Diseased Herds Studied

One herd of the six studied experienced an acute infection of leptospirosis and details of the course of the disease will be of interest. This herd consisted of 1 bull, 25 cows, 10 heifers, 5 steers, and 8 calves. Agglutination-lysis titres were determined of bleedings taken from animals in the herd at intervals—in November and December of 1956, and February and May of 1957.

In the summer of 1954, a cow calved and three weeks later died suddenly about 12 hours after she was first noticed to be ill. No further trouble occurred until October 1956 when a second cow showed a drop in milk production,

increased respiration, and blood in her urine. Her temperature had risen to 103° when taken by the local veterinary the following day. The dark brown color of the urine persisted for six days and the milk remained yellow and thick for a few days then returned to normal. This cow was not in calf at the time and since has been bred successfully once. Following the clinical disease in this animal, three cows aborted and 13 other adult cows showed serological reactions of a high order. Most of the 13 cows had reached the fifth or sixth month of pregnancy at the time of the acute outbreak in the herd and one was in the ninth month of gestation. None of the 13 aborted or showed other clinical evidence of leptospiral infection. This study shows the frequency with which subclinical infection may occur in a leptospirosis outbreak and the importance of keeping this point in mind when interpreting results of serological tests. Sterility followed later in five cows that showed serological reactions but there is no proof that the earlier leptospiral infection contributed.

In three of the other five herds studied, only one animal in each herd exhibited clinical symptoms of leptospirosis such as bloody urine and abortion. A few of the remaining animals developed weak serological reactions. In the fifth herd studied, one cow aborted, and one which showed blood in the urine and weakness died a few months after calving. Her calf, which was born weak, died a few days later. Serological reactions of low order were observed in tests on two other cattle. In the sixth herd, composed of beef cattle, one animal died six days after the onset of acute symptoms resembling leptospirosis. Three months later the entire herd reacted serologically to *Leptospira sejroe*, another serotype sometimes encountered in cattle infection.

Disease Not Easily Controlled

Prevention and control of leptospirosis by hygienic measures proves difficult considering that clinically recovered animals remain carriers of leptospiras for varying lengths of time. Subclinically infected animals, often overlooked by the owner, present a real hazard. Additions to a herd should not be made without an isolation period during which blood samples should be sent to the laboratory to confirm absence of infection.

Some workers have recommended immunization of cattle with vaccine but it is difficult to establish its value because the severity of different outbreaks varies so much. At best, immunity is claimed to last only 6 to 12 months making it necessary to re-vaccinate once a year. As treatment, various antibiotics have helped to alleviate the symptoms at the acute phase of the disease but their use to control the carrier stage has met with less success.

Author (left) inoculating suspected urine into guinea pigs in attempt to isolate the causative agent.

New Livestock Insect Laboratory, Guelph, Ont.

Livestock insect investigational work in Eastern Canada received added impetus recently with the completion and occupancy of a new Canada Department of Agriculture entomology research laboratory at Guelph, Ont. The new building was erected at a site provided on the campus of the Ontario Agricultural College at Guelph. Since 1954, livestock insect research at Guelph has been carried on in a laboratory established in temporary quarters at the Ontario Veterinary College. Work at the new laboratory will include a comprehensive study of insects affecting animals and man in Eastern Canada and the development of improved control measures.

Beef cattle on mixed forage pasture at Illustration Station on the farm of D. A. MacRae, Williamstown, Ont.

Use of Fertilizer for Pasture and Hay Crops in Eastern Canada

B. J. Finn

AND

D. A. Duncan

MANY farmers fail to get maximum returns from their pasture land. Beef production, for example, averaging less than 200 pounds per acre on unfertilized pasture has been tripled by proper fertilization and management.

Effect of Fertilizer on Pasture Yields

No crop is so much in need of improvement as is natural pasture. Most of these pastures are producing at less than 50 per cent of their capacity. Fertilizer applications on natural pasture in Eastern Canada increased dry-matter yields by as much as a ton or more per acre. Results of these experiments, conducted on Illustration Stations, are shown in Table 1. Returns were measured in terms of pounds of beef per acre, assuming that 8.1 pounds of dry matter were needed to make one pound of beef, and valuing the beef at 20 cents per pound.

The largest return of $103 per acre after subtracting fertilizer cost, resulted from an annual application of complete fertilizer. Phosphorus alone applied every three years was more economical than either nitrogen or potassium or both in terms of yield increases.

Effect of Fertilizers on Mixed Hay

In general, farmers apply fertilizers for both grain and hay crops at seeding time which means that the fertilizer requirements for both crops must be considered. Table 2 shows the residual effect of fertilizer elements on the grain and hay crop yields and the net returns over fertilizer cost in tests at Ottawa. Returns are calculated on the basis of oats at 50 cents per bushel and beef at 20 cents per pound, assuming that 10.5 pounds of dry matter are required to produce one pound of beef.

The fertilizer applied to the oat crop did not, in all cases, produce increased hay yields. For example, 20 pounds of nitrogen per acre produced lower hay yields than 10 pounds of nitrogen. This

Dr. Finn is a Soil Fertility Specialist with the Field Husbandry, Soils and Agricultural Engineering Division. Mr. Duncan is a Soils Specialist with the Illustration Stations Division. They are located on the Central Experimental Farm, Ottawa.

TABLE 1 AVERAGE YIELDS ON FERTILIZED PASTURE AND RETURNS OVER FERTILIZER COST ON ILLUSTRATION STATIONS IN EASTERN CANADA, 1944–1955 (12 YEARS) POUNDS OF DRY MATTER PER ACRE

Treatment* lb. per acre	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	All Stations Av.	Gross Return Av.	Fertilizer Cost Av. per Acre	Net Return Av.
No fertilizer	3360	2304	2144	2356	2068	2446	61.20	0	61.20
0–120–0 every 3 years	4340	4692	3092	3192	3096	3682	92.00	4.80	87.20
0–120–60 every 3 years	4512	4736	3372	3428	3328	3875	96.80	6.00	90.80
20–0–0 annually, 0–120–60 every 3 years	4984	5140	3760	3676	3560	4220	105.40	9.40	96.00
20–120–60 annually	6608	5592	4540	4096	4076	4982	124.40	21.40	103.00
No. of tests (12 years)	47	122	89	311	133	702			

*Treatments: 0–120–0 represents 600 lb. of superphosphate (20%).
0–120–60 represents 600 lb. of superphosphate (20%) plus 100 lb. muriate of potash (60%).
20–120–60 represents 600 lb. of superphosphate (20%) plus 100 lb. muriate of potash (60%) plus 100 lb. of ammonium sulphate (20%).

TABLE 2 EFFECT OF FERTILIZER ON YIELDS OF OATS AND MIXED HAY ON SANDY LOAM, LOAM AND CLAY SOILS—RETURNS OVER FERTILIZER COST CENTRAL EXPERIMENTAL FARM, OTTAWA, ONT.

Treatment* pounds per acre			Yield per acre		Gross Returns		Fertilizer Cost	Net Return
N	P_2O_5	K_2O	Oats bu. per acre	Hay lb. dry matter per acre	Oats at 50 cts per bu.	Beef at 20 cts per lb.		
No fertilizer			43.9	2343	21.95	41.60	0	66.55
(Nitrogen series)								
0	200	200	19.9	4216	24.95	80.40	36.00	69.35
10	200	200	57.3	4505	28.65	85.80	37.70	76.75
20	200	200	61.8	4352	30.90	83.00	39.40	71.50
(Phosphorus series)								
10	0	200	56.0	3094	28.00	59.00	13.70	73.30
10	50	200	58.5	3893	29.25	74.20	19.70	83.75
10	100	200	59.2	4182	29.60	79.60	25.70	83.50
10	200	200	62.7	4607	31.35	87.80	37.70	81.45
(Potassium series)								
10	200	0	52.0	4114	26.00	78.40	25.70	75.10
10	200	50	51.8	4301	25.90	82.10	28.70	79.30
10	200	100	58.4	4505	29.20	85.80	31.70	83.30
10	200	200	61.0	4590	30.50	87.40	37.70	80.20

*Example: Treatment 10-200-200 is equivalent to 50 lb. of ammonium sulphate (20%), 1000 lb. of superphosphate (20%), and 400 lb. of muriate of potash (50%).

might be expected on the basis that much of the nitrogen was utilized by the grain crop. Furthermore, since the hay mixture was predominantly alfalfa and red clover one would not expect high rates of nitrogen to be productive. Each increment of phosphorus (P_2O_5), from 50 to 200 pounds per acre, produced an increase in hay yields. Potassium (K_2O) produced only a slight increase in hay yield above the 100 pound per acre rate.

On the basis of grain and hay yields the highest net returns were obtained from the 10 pound rate of nitrogen, the 50 pound rate of P_2O_5, and the 100 pound rate of K_2O.

RESULTS FROM OTHER TRIALS

On the basis of forty fertilizer trials, conducted over a period of several years in the Ottawa district, fertilized pastures produced, on an average, 63 per cent more dry matter than unfertilized areas. Fertilizer also improved the composition of pasture, increasing the clover stand by 50 per cent and decreasing the weed population by 30 per cent.

In the province of Quebec, at Lennoxville, Ste. Anne de la Pocatiere, and Normandin average increases in yield of approximately 45, 55, and 62 per cent, respectively, were obtained by fertilization. In the Maritime Provinces at Fredericton, N.B., Nappan, N.S., and Charlottetown, P.E.I., fertilized pastures produced over 50 per cent more herbage than unfertilized pastures.

Effect of Time of Application

The importance of time of application of mineral fertilizers, phosphorus and potassium, to a hay crop is shown in Table 3. An application of 120 pounds of P_2O_5 on the oat stubble produced a yield of 5,542 pounds compared with 4,693 pounds where a similar amount was applied to the oat crop at seeding time. This is an increase of 849 pounds of dry matter per acre. In the case of K_2O fertilization, the time of application does not appear to be so important.

CARLETON COUNTY TRIALS

Fertilizer experiments were conducted over a 13-year period on different soil types in Carleton County, Ontario. Soils varied in texture from sand to clay and results were as follows: Nitrogen applied to the oat crop decreased the yield of first-year grass-legume hay by an average of 232 pounds of dry matter per acre. Phosphorus treatments increased the yield of hay, particularly on the finer textured clay soils, showing an average increase for all tests of 771 pounds of dry matter per acre. Applications of potassium on coarse textured sandy soil resulted in a slight increase in the yield of hay of 205 pounds of dry matter per acre. On the fine textured clay soils no increase was obtained.

The net returns over fertilizer cost were higher from an application of 120 pounds of P_2O_5 on the oat stubble than when applied to the grain crop at seeding time. In the case of potassium a split application of 50 lb. K_2O on the oat seeding and 50 lb. of K_2O on the oat stubble produced the highest yield and return per acre.

Other experiments conducted by Experimental Farms indicate that a mixed hay crop will respond equally well to mineral fertilizers, whether they be applied directly

Concluded on page 9

TABLE 3—EFFECT OF FERTILIZER ON YIELDS OF OATS AND MIXED HAY—RETURNS OVER FERTILIZER COST CENTRAL EXPERIMENTAL FARM, OTTAWA, ONT.

Treatment—lb. per acre	Fertilizer on		Yield per acre		Gross Return*		Fertilizer Cost	Net Return
	Oat seeding	Oat stubble	Oats bu.	1st yr. hay lb. dry matter per acre	Oats at 50 cts bu.	Beef at 20 cts lb.		
No fertilizer			44.4	2125	22.20	40.60	0	62.80
PHOSPHORUS SERIES	P_2O_5	P_2O_5						
50 lb. K_2O at seeding and 50 lb. on oat stubble	0	120	51.2	5542	25.60	105.60	20.40	110.80
	30	90	59.0	5474	29.50	104.20	20.40	113.30
	60	60	59.1	5610	29.55	106.80	20.40	115.95
	90	30	59.6	5219	29.80	99.40	20.40	108.80
	120	0	61.9	4693	30.95	89.40	20.40	99.95
POTASH SERIES	K_2O	K_2O						
60 lb. P_2O_5 at seeding and 60 lb. on oat stubble	0	100	57.9	5355	28.95	102.00	20.40	110.55
	25	75	55.5	5110	27.75	103.60	20.40	110.95
	50	50	59.1	5611	29.55	107.00	20.40	116.15
	100	0	58.7	5338	29.35	101.60	20.40	110.55

*Gross returns on basis of oats at 50 cts per bu. and beef at 20 cts per lb. Calculations based on the assumption that 10.5 lb. of dry matter (hay) are required to produce one pound of beef.

Left: Section through greatly enlarged aphid (actual size: grain of sand) feeding on plant stem; notice needle-like mouthparts inserted into stem. *Inset:* Aphids feeding on small stem. *Right:* Plant infected about two weeks with aphid-borne virus; healthy control on right. A single aphid transmitted virus to plant in less than a minute.

Aphids and Virus

R. H. Bradley

EVERY farmer is familiar with the crop damage that may result from attacks of aphids. Reduced yields, misshapen fruits, or disfigured flowers and vegetables are common examples. There is another more subtle way in which aphids cause trouble—as carriers of viruses. This aspect of the aphid problem is receiving special study at the Crop Insect Laboratory Fredericton, N.B., with particular emphasis on how aphids transmit viruses mechanically.

Though little larger than grains of sand, aphids transmit more plant viruses than any other group of insects. A single aphid can infect several plants. Over 50 aphid-borne viruses have been reported and hardly a country is free of them, nor are many crops. Among the crops they infect are cabbage, carrots, celery, cereals, corn, cucurbits, hops, lettuce, onions, ornamental flowers, potatoes, radish, small fruit, sugar beets, sugar cane, tobacco, tomatoes, and various fruit trees.

Aphids feed by inserting their needle-like mouthparts and imbibing liquids that otherwise would be used by the plant. They transmit virus by inserting their mouthparts first into infected then into susceptible plants. Although there are two main types of virus transmission by aphids, mechanical and biological, most viruses are transmitted mechanically.

Dr. Bradley is a Specialist on Insect Transmission of Plant Viruses at the Department's Entomology Laboratory, Fredericton, N.B.

Virus Transmitted Quickly

In mechanical transmission aphids readily acquire and inoculate virus within seconds after beginning to probe; the entire process can be completed in less than a minute. Under experimental conditions aphids transmit such viruses optimally if first kept from feeding for a while, then are allowed to probe into infected plants for about half a minute, and immediately transferred to susceptible plants. If aphids spend longer than a few minutes on infected plants, the number of insects that transmit virus decreases rapidly during the first hour. After that time, the ability to transmit disease remains more or less constant at a comparatively low level. Once aphids leave infected plants, they inoculate virus only a few times at most. They usually cease to be able to do so within minutes and always within hours.

A simple explanation of these facts is that, during probing, the mouthparts become contaminated with virus, which later is introduced to susceptible plants during subsequent probing. But other facts clearly show that there is still much about this transmission that is not understood. It has been found that most viruses transmitted mechanically by aphids are also readily transmitted manually by rubbing sap from infected plants on to susceptible ones. Yet some of the viruses most readily transmitted by rubbing are *not* transmitted by aphids. Also, the efficiency of transmission by aphids varies with different species, though not always the same way with different viruses. For example the four species of aphids that infest potato vary in their efficiency of transmission of potato virus Y from over 70 per cent to less than 10 per cent. In a more extreme example a plant can be infected simultaneously with two viruses; one species of aphid transmits the first but not the second, whereas another species transmits the second but not the first. Mechanical transmission by aphids appears

to involve more than the mouthparts merely acting as an inoculating needle.

Probing Spreads Virus

Studies by Department scientists have revealed that for reasons not yet fathomed, only the tips of the mouthparts carry virus, though much more than these are inserted during feeding. Feeding does not seem to play the part in mechanical transmission that it does in biological. Aphids acquire and inoculate virus mechanically during superficial probing when little or no food is ingested.

This superficial probing is what aphids often do before settling down to continuous feeding; it seems the aphid first somehow tests the suitability of the plant or the particular feeding site. If the results of this probing are satisfactory to the aphid, it inserts its mouthparts deeply into the plant, usually to vascular tissues, and feeds uninterrupted for hours or even days. At such times aphids rarely acquire virus that they transmit mechanically, and they soon lose any they acquired during the preliminary probing. In nature, transient aphids—those that probe briefly and then move to other plants—are the most apt to transmit virus mechanically.

Epidermis Inoculated

There is evidence that aphids usually acquire and inoculate virus mechanically as their stylets penetrate the first layer of cells, but not after they penetrate beyond this. Hence, infection starts from virus that the aphid inoculates to the epidermis. In this respect, these infections resemble those caused by manual inoculation, for here, too, infection starts from virus that enters epidermal cells through wounds made by rubbing. Virus workers in different countries including Canada have discovered various treatments that inhibit virus infections by rubbing inoculation. Several of these treatments were therefore tested against virus inoculated mechanically by aphids, and some of them stopped most infections.

The most promising results were obtained with a substance called *trichothecin*, which is produced by a fungus after which it

How an aphid probes. (A) Head of aphid with beak extended for probing. (B) Mouthparts extended beyond end of beak showing distance they are inserted during superficial probing and when virus is transmitted mechanically. (C) Distance mouthparts inserted for *feeding* and when virus is transmitted biologically.

is named. Most plants remained healthy if they were sprayed with dilute solutions of trichothecin either before or after aphids inoculated them mechanically with virus. It is thought that trichothecin changes the metabolism of epidermal cells so that inoculated virus does become established.

Of course, much remains to be done before claims can be made for the practical use of trichothecin or any other substance that causes similar results. But the results to date show that growers may soon be able to make their plants resistant to infection by viruses that aphids transmit mechanically.

Biological Transmission

As mentioned earlier, in most cases virus transmission by aphids is purely mechanical. There are, however, a few cases where aphid-borne virus is transmitted biologically. In Canada the best known example is that of potato leaf roll virus.

To acquire virus that is transmitted biologically, an aphid must *feed* on infected plants for a considerable time, usually hours. Immediately after acquiring it, however, the aphid cannot inoculate it for a period of from several hours to a few days, depending on the virus; but following this period the aphid can inoculate virus over and over for days and often for life. The longer aphids feed on infected or susceptible plants the more apt they are to transmit such viruses, but it is rare for them to do so during feeding periods of less than an hour. Virus seems to be ingested with the aphid's food, passes through the gut wall, thence to salivary glands and into the plant.

Use of Fertilizer for Pasture and Hay Crops . . . *from page 7*

to the hay crop in the fall of the year seeded or in the following spring.

Among the factors to be considered in determining the kind and quantity of fertilizer for any particular crop are the nature of the soil and the previous treatment of the land. Information relevant to soil texture, drainage, lime requirement, and the availability of plant food constituents is most helpful in deciding the fertilizer needs of a crop. Some of this information can be obtained from an analysis of a sample of soil from the area.

Hay and pasture crops provide the most economical source of feed for the production of milk and beef and consequently are the foundation of our dairy and livestock industry. Proper fertilization and management of these crops will pay dividends.

Wild oats is a very difficult weed to control where wheat is grown in a grain rotation.
Inset: A 30 per cent infestation of wild oats.

Wild Oats in Western Canada

H. W. Leggett AND *J. D. Banting*

In Western Canada wild oats are the number one weed problem in cereal crops and are responsible for half the total weed bill. As far back as 1931, surveys showed that 85 per cent of the cultivated acreage in the Prairie Provinces was infested. Nearly one half of this area was heavily infested, one quarter was moderately infested, and the remainder carried a light infestation.

The reduction in yields of various crops directly attributable to wild oats is also staggering. Experiments have revealed that even a medium infestation reduced the yields of barley, our best competitor crop, by 16 per cent, wheat by 33 per cent, oats by 49 per cent, and flax, which provides little or no competition with weeds, by 84 per cent.

We still have no method of adequately controlling wild oats, but it is hoped that basic studies being carried out at Saskatoon, Regina, and Ottawa may soon reveal the chink in the heretofore impregnable armor of the wild oat. The chief difficulty in eradicating wild oats is the persistence of seeds in the soil. Several important factors have a bearing on the problem. (1) Since one wild oat plant can produce 250 seeds even a light infestation can assume serious proportions very quickly. (2) Unlike the cultivated forms, wild oats shed their grain during maturation. (3) Delayed germination is a characteristic of wild oats. (4) Environmental factors such as temperature, oxygen supply, and soil moisture affect germination. We need to know more about these factors, and the reasons for delayed germination so that more effective controls can be developed.

COUNTING THE COST

The magnitude of the problem is clearly evident from the amount of wild oats that reaches our terminal elevators. The average yearly dockage in carloads, from 1924 to 1950, was 6,430. Grain officials estimate that one third of this was wild oats. Assuming this to be true, we ship approximately 2,143 carloads of wild oats to our terminal elevators each year. This is over 4,000,000 bushels annually. Yet survey reports indicate that this is only one fifth of what we actually produce.

Meanwhile cultural methods of controlling wild oats are proving helpful. *Delayed seeding*, using an early maturing barley crop, is the best method. Supplementary measures, such as fall tillage, light early-spring cultivation, post-seeding cultivation, and fertilization will increase the percentage of control. Fall tillage is beneficial provided it is done two to three weeks after harvesting. Light early-spring cultivation helps to promote earlier germination. Post-seeding cultivation, preferably with a rod weeder, and under conditions suited to its use, gives the crop a chance to get ahead of the wild oats. Fertilizers, unless used with some other method, are not of value, but used in the overall program they give the crop an advantage over the weeds. There is, however, one important limiting factor in any one year. Climatic conditions determine the success or failure of cultural control measures. For

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example, when the weather is cool and moist, fall tillage usually gives poor results. On the other hand, when weather conditions in the spring permit rapid germination of wild oats, delayed seeding gives excellent control. However, should cool, moist weather prevail throughout the growing season, delayed seeding may not be satisfactory.

Fall-seeded crops have proved advantageous where it is possible to use them. Since only a relatively small acreage in Western Canada is a good fall crop risk, this method has only limited usefulness. *Rotations* that include grass or a grass and legume mixture have, under some conditions, given adequate control. However, unless carried on for a great many years such rotations have not been an outstanding success. *Seeding down to grass* for varying periods of time, on heavily infested areas, has in only a very few cases given good control. Usually sod tends to preserve wild oat seeds for up to ten years. *The use of inter-tilled crops* is not practical on the Prairies even though with thorough cultivation excellent results are obtainable over a relatively few years. *Green feed crops* that are cut before the wild oats come into head are practical and efficient as a control measure but this method has only limited application.

In chemical control of wild oats, studies have proceeded along three main avenues. First, pre-emergence treatments have been explored hoping for a chemical that would be selective enough to kill the wild oats as they emerge without harming the crop. This has proved partially successful in that chemicals were found that were effective. Unfortunately, however, the crops concerned are not our common cereals.

The second approach was to find a chemical that could be sprayed on the wild oats in the standing crop, that would not seriously damage the crop but would devitalize or otherwise impair the developing wild oat seeds. The chemical maleic hydrazide sprayed on at the correct stage of growth had no adverse effect on the crop. When sprayed on the wild oats in the early milk stage the wild oat seeds either did not form or if they did they failed to germinate. Unfortunately, under natural conditions, when the crop was at a stage when no harm would be done, the largest percentage of the wild oats were also at a similar stage and were unharmed. The critical timing necessary for successful results never materialized under natural field conditions.

With the third approach—pre-seeding treatments—by far the largest number of chemicals have been screened. There are three possible methods of attack. These involve the use of a chemical that will: (1) destroy the germinating seedlings of wild oats but will not persist in the soil long enough to damage the germinating seedlings of a crop seeded later; or a chemical selective enough to destroy the wild oat seedlings and not harm the germinating seedlings of the crop; (2) destroy the germinability of the wild oat seeds in the soil and not persist long enough to harm the later seeded crops; or (3) break the dormancy of the wild oats thus allowing them to grow and be destroyed by cultivation.

Promising chemicals must ultimately prove themselves in field tests. This is a necessary feature of the final screening, but it is both costly and time consuming. In our future program we intend to supplement field tests with relatively inexpensive laboratory tests. In this way we hope to develop a faster and more efficient screening process, and eventually find a chemical that will somehow control wild oats.

Research Aid

New Method Developed for Inducing Dormancy in Wild Oat Seeds

For basic studies on wild oats in which dormancy of the seed is involved, the research worker must have a constant supply of dormant seeds. This has been a problem, for when wild oat seed is harvested and stored in the laboratory the dormancy of the seed begins to decline.

A laboratory method of inducing dormancy in wild oat seeds has recently been developed by Dr. J. R. Hay of the Field Husbandry Division, Central Experimental Farm, Ottawa. He found that dormancy may be induced by soaking the seeds in air-free water under certain temperature and light conditions. Exhaustive tests have indicated that this induced dormancy resembles natural field dormancy. It is hoped that the Hay discovery will facilitate research studies on wild oats, designed to kill dormant seeds or to break dormancy.

Upper: Removing hulls from wild oats to test percentage germination of dehulled seed having induced dormancy.

Lower: Two lots of wild oats seed started six days before photo was taken. Non-dormant seed (left) and seed with induced dormancy (right).

Left: Red pine plantations and a natural stand. Mulmur Township, Ont. *Below:* *Fomes* annosus infection experiment with four different tree species. St. Williams, Ont.

Forest Plantation Disease Problems in Ontario

Erik Jorgensen

DURING the last 50 years there has been a substantial development in the establishment of plantations of forest trees in southern Ontario. These plantations present a picture of vegetation, uniform in kind and size, that stands in sharp contrast to natural woodlots which contain a variety of species in different age-classes.

The beneficial influence of this reforestation of cleared land that is no longer suitable for agricultural crops is becoming increasingly evident. Tree planting is often the only effective means of controlling soil erosion. Plantations act as windbreaks around fields and farms and as water regulators on watersheds cleared in error by early settlers. Furthermore, production of forest crops on otherwise unproductive land helps to increase the income of the farmer.

In these plantations emphasis has been on conifers and the total area of coniferous plantations in Ontario now exceeds 100,000 acres. A further increase in the area planted to forests may be expected to follow the current establishment of new forest nurseries with its consequent increase in the annual production of planting stock.

Like any other crop, tree plantations suffer their share of attacks from disease. Because of the rapidly expanding planting program in Ontario, a study of plantation diseases was begun in 1955 at the Forest Pathology Laboratory at Maple, Ontario.

Most disease conditions in plantation trees are the result of the activity of one or several, more or less pathogenic micro-organisms in the presence of environmental factors unfavorable to the resistance of the host. Although, as might be expected, the same diseases are found in plantations as in the natural forest, their development and consequently their importance is often quite different in the two plant societies. Fungi that are of minor importance in natural stands can cause serious diseases under plantation conditions, while diseases that are of economic importance in the natural forests may prove to be of little consequence in plantations.

Differences in pathology of the same tree species under plantation and natural stand conditions are frequently due to differences in environment. For example, most of the plantations consist of even-aged stands of single tree species that under natural forest conditions are seldom found in pure stands. Furthermore, tree species in plantations are often established outside their natural range and on

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This Laboratory is operated jointly by the Ontario Department of Lands and Forests and the Forest Biology Division, Science Service, Canada Department of Agriculture, under the terms of a co-operative agreement for research in forest pathology and entomology in Ontario.

sites where they would have been unable to form stands in natural competition with other tree species. Thus special disease problems in plantations are brought about by the conversion of our wild tree flora into a cultivated crop.

The study of plantation diseases, in common with all other fields of plant pathology, has disease control as its final aim. However, in plantations the means that can be employed to reach this goal are economically limited by the long crop rotation compared with that for other crops and by the relatively low value of the tree crop. Therefore, spraying with fungicides, the common method of plant disease control, will seldom be feasible in forest plantations. The control of plantation diseases must depend mainly on silvicultural methods—thinning, pruning, soil improvement, and crop rotation.

A thorough understanding of the ecology and biology of both the pathogen and the host is of prime importance in correctly diagnosing a disease condition and in formulating a control program for forest plantation diseases. To date, the Ontario project has placed emphasis on studies of canker and root diseases that now present serious or potentially serious problems in plantations. Some results and conclusions of these investigations reflect the complexity of plantation diseases.

Cankers Common in Spruce

A branch and stem canker disease of spruce was found commonly distributed on white and Norway spruce in shelterbelts and plantations. The cause, identified by means of isolations, infection experiments and reisolations, proved to be an ascomycete: *Valsa kunzei* Fr. var. *picea* Waterman. The perfect stage of the fungus was found on dead branches while the imperfect stage, *Cytospora kunzei* Sacc., could be found only on the border of active cankers. Infection experiments showed that, while it was impossible to obtain infections without wounding the bark, mycelium inoculated into wounds in the bark prevented them from healing over. Thus the fungus was proved to be a wound parasite. Since wounds in the bark caused by insects and birds are of frequent occurrence and because of the wide geographical distribution of the fungus, the disease appeared to be potentially serious.

White spruce with resin flow from a stem canker caused by *Valsa kunzei*, var. *picea*. Provincial Forest Nursery, Orono, Ont.

An analysis was made of the growth of 60 trees from three different localities, chosen so that 30 trees were completely healthy and 30 trees had severe stem cankers as well as branch cankers. This showed that the annual diameter growth of all cankered trees had been depressed below that of the healthy trees for at least one year before the canker infection occurred on the stems. It was also found that the incidence of branch cankers increased with stand height and that the branch cankers developed mainly on overshaded branches. The reduction in diameter growth of stem-cankered trees was found to be related in part to the crowding of the trees and in part to the occurrence of a special growth pattern found in two types of trees: the 'wolf' tree and the 'whipper' tree. These types of trees have a rapid initial growth which they are unable to maintain.

However, the loss of branches due to branch cankers does not significantly affect the capacity of the tree to produce wood and only the stem-deforming cankers are considered of importance in forestry. It can therefore be concluded that, although the spruce canker appears to be a very serious disease, in a managed forest it will be of little importance if a sustained diameter growth is secured for all the desirable trees through proper thinnings started early and repeated at 2- or 3-year intervals.

These studies of the spruce canker serve to illustrate an interaction between parasite and host, in which predisposition to the disease is unrelated to site factors. However, variation in the site was found to be a determining influence in the development of a root-rot disease caused by *Fomes annosus* (Fr.) Cke.

Root Rot in Jack and Red Pine

Fomes annosus, the organism responsible for root rot in pine was recorded for the first time in Ontario in 1955 in a red pine plantation at the Provincial Forest Nursery at St. Williams. Since then it has been found at two other localities, also in plantations, and the local host list now includes seven coniferous tree species. The fungus has not been reported in natural stands in the Province. Nevertheless, *F. annosus* is believed to be a native fungus which becomes an important pathogen under the special conditions created by plantations.

Extensive killing of jack pine and red pine by this fungus has been found in plantations at St. Williams, one of the oldest planta-

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Root system of red pine attacked by *Fomes annosus* (lower left). Note fruiting body formation on roots and shallow root layering compared with healthy root system of red pine from some stand (lower right) which has deep root layering. St. Williams, Ont.

Controlling Weeds With Insects

J. Morris Smith

Author releasing adults of Chrysolina beetle (right) at Edgewood, B.C. Paper and cartons burned later as safeguard against importation of weed seeds.

Many of our worst weeds have been imported into Canada from other countries. In most cases they have been unaccompanied by the natural enemies that keep them in check in their native lands. A relatively new technique—the use of imported insects for weed control—shows considerable promise.

Weeds that lend themselves best to control by insects are those farthest removed botanically from economically valuable plants. Many insects feed only on the plants of a single genus but have little preference for a single species within the genus. Before we can introduce insect enemies as weed control agents, a search must be made for species that feed on the particular weed in its native home. Such insects must of course be investigated carefully both before and after importation to make as sure as possible that they will confine their feeding to the weed in question and not attack crop plants.

Common St. Johns-wort

First attempts in this country to employ insects for weed control were carried out in British Columbia against the common St. Johns-wort, a problem weed on millions of acres of rangeland in the southern part of that province and in the adjoining northwestern United States. St. Johns-wort may cause severe dermatitis when eaten by livestock but its major crime is to crowd out valuable range forage plants. While cultural methods of control are effective, they are not feasible on large areas of rough rangeland. Chemical control is impractical for the same reason and because the cost of each application of herbicide would exceed the value of the land treated. Under these circumstances, biological control offers interesting possibilities. Where successful, it overcomes these obstacles and obviates the necessity of annual treatments.

A few years ago, Australian entomologists conducted careful starvation tests in Europe on several insects known to be specific to St. Johns-wort. Some of these were transferred to Australia, tested again under quarantine conditions and then released on infestations of the weed. Two of them, the leaf-eating beetles *Chrysolina gemellata* Rossi and *C. hyperici* Forst., became established but achieved only local control of the weed. Colonies of these two beetles that were transferred to California in 1945 and 1946, however, increased spectacularly. *C. gemellata,* in particular, during the period 1946 to 1951, practically eradicated dense infestations of St. Johns-wort that covered hundreds of square miles of California rangeland. These beetles were later released in some regions of Idaho and Oregon where they achieved satisfactory but less spectacular control.

When *C. gemellata* and *C. hyperici* were further investigated at the Entomology Laboratory, Belleville, Ont., in 1950 we found that they would feed on several St. Johns-wort species, a few of which are native to marshy areas of Canada but they did not survive on any crop plants. These beetles and the Colorado potato beetle, another member of the same insect family, are equally specific in their food requirements; the former feeds only on St. Johns-wort and the latter only on the potato and its near relatives. In Europe, *C. gemellata* and *C. hyperici* have been known for more than 150 years to feed only on St. Johns-wort species.

Between 1951 and 1954 approximately 75,000 adults of *C. gemellata* from California and Idaho, and 20,000 adults of *C. hyperici* from California and Oregon were released in seven localities in the Okanagan, Kettle, Columbia, and eastern Kootenay Valleys of British Columbia.

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Infestation of St. Johns-wort at Westbank, B.C.

Under Canadian climatic conditions the adult beetles, after they have overwintered in the surface soil, deposit their eggs on the procumbent, basal shoots of the St. Johns-wort. The larvae that hatch from these eggs resemble those of the Colorado potato beetle in appearance and feed gregariously on the tender, basal leaves. When fully fed they pupate in debris or in the soil. The new generation of adults emerges in late June. These adults feed voraciously on the upright flower stalks; this, combined with feeding by the larvae, weakens the plants severely. After feeding for about three weeks, the young adults enter the surface soil and remain quiescent through the hot, dry, summer period. The autumn rains stimulate beetle activity, as well as the growth of fresh green food, and mating takes place almost immediately. In Northern California greater rainfall and higher temperatures during the autumn and winter months provide more favorable conditions for egg laying and larval development than in British Columbia, with the consequent phenomenal increase in populations.

The seven *Chrysolina* colonies have survived three to six winters in British Columbia. Only the colony of *C. hyperici* at Fruitvale, however, has achieved significant control of the St. Johns-wort: approximately one quarter of a dense, five-acre infestation has been cleared of the weed. Thousands of beetles have been collected in this colony for distribution in other infestations in British Columbia.

Two other insect enemies of St. Johns-wort, a bronze-colored, root-boring beetle and a delicate, gall-forming midge, obtained originally in Australia were imported into British Columbia from California, as possible agents of control. These insects were first investigated in Europe, their native habitat, prior to shipment to Australia. They have been most valuable in California, though less spectacular than *C. gemellata*. It is still too early to assess the degree to which they have established themselves in Canada.

Toadflax

A more recent project has been the investigation of toadflax or butter - and - eggs. This plant appears to be kept under satisfactory control by natural agents in all parts of the world except the Prairie Provinces of Canada. This is the only known area in which expensive control measures are needed. A tiny, gray weevil that destroys the seeds of toadflax is absent in this region although it occurs commonly in all known infestations of the weed in the remaining provinces of Canada and in the northwestern and northeastern United States. This weevil causes no damage to horticultural varieties of toadflax and snapdragon under normal conditions, as determined by our investigations at Belleville. Accordingly, 4,000 adults were collected in 1957 in the vicinity of Belleville and were transported in iced containers for direct release in west-central Saskatchewan and in the Peace River District of Alberta. Although one generation has developed in each of these areas, the ability of the weevils to survive the low winter temperatures will not be known until July of this year.

The toadflax weevil overwinters in the adult stage among debris or in the surface soil and deposits its eggs in the seed capsules from June to August. The larva feeds on the immature ovules and then pupates in a small cell in the seed capsule. Adults emerge in August and September and then either begin a second generation or overwinter. In August, 1957, at Belleville, one man was able to gather in two hours more than 3,000 freshly emerged adults, none of

PUTTING THE BUGS TO WORK

Already some of the attempts at weed control by means of introduced insects have produced spectacular results. The classical example is the control of prickly pear cactus which had overrun 60 million acres of good rangeland in Australia. Control was accomplished by means of a moth imported from Argentina. The larvae of this insect bore into the cactus pads, allowing entry of spores of fungi which complete the destruction of the plant. "Koster's curse", a weedy shrub that was truly a curse in the pastures of Fiji, was satisfactorily controlled by the introduction of a species of thrips that feeds only on this weed. On the island of Mauritius a leaf-eating beetle, transferred from Trinidad in 1947, destroyed large acreages of an aggressive shrubby weed known as black sage. A troublesome weed in Hawaii, pamkani, closely related to our Joe Pye weed and boneset, was recently reduced to non-economic proportions by a stem gall fly imported from Mexico. And in California, the biological control of St-Johns-wort provides the outstanding success story in North America.

Release of 12,500 adults of *Chrysolina gemellata* at Edgewood, B.C. *Inset:* *C. gemellata* feeding on St. Johns-wort plants.

***Chrysolina* larvae feasting on common St. Johns-wort. *Inset:* Close-up of beetle pupa.**

which reproduced during the remainder of the flowering season.

Another insect, a small, black, pollen-feeding beetle, whose larvae feed exclusively on toadflax ovaries and stamens, occurs in sufficient numbers in Saskatchewan and Alberta to prohibit bloom in July. It is obviously not exercising adequate control, however, because the weed is spreading at an alarming rate. This insect occurs commonly in Ontario and may supplement the control by the weevil.

Other Weed-eating Insects

Thousands of acres of sagebrush, so familiar in the semi-arid regions of western North America, have been cleared by a leaf-eating beetle in the vicinity of Kamloops, B.C. This olive-green beetle was collected in that area several years ago but only recently has demonstrated its ability to control the weed. Improvement in the vigor and density of blue grass and other grasses was immediately apparent in response to the greater supply of moisture and nutrients formerly used by the sagebrush. However, there is as yet no reason to believe that control by the beetle may be anything but temporary, caused by a temporary population increase from exceptional causes.

The present insignificant status of some of our weeds may be attributed to insect enemies that check their increase. Common burdock, for example, though always a nuisance, could conceivably be a serious problem were it not for the fact that most of its seeds are destroyed by a small, white caterpillar. Field bindweed might be a more important weed in Ontario but for the defoliation caused by two or more species of tortoise beetles. Two close relatives of the sagebrush beetles are beneficial in Ontario; one defoliates prickly ash and the other goldenrod.

Biological control of weeds offers many advantages over other control measures, particularly with plants resistant to herbicides, or weeds on inaccessible, low-value rangeland. However, insects imported for controlling weeds biologically must be carefully investigated both before and after importation, before colonies can be released in Canada. Risk of the imported insects changing their food preferences, though unavoidable, is not greater than the chance of native, plant-feeding insects adapting themselves to crop plants. There is no record of any insect, imported for the control of weeds, damaging crops.

Forest Plantation Disease Problems in Ontario . . . *from page 13*

tion areas in Ontario. Investigations of a jack pine and a red pine stand in this area have revealed a correlation between mortality caused by the fungus and root development of the trees, which is determined by the soil conditions. In the red pine stand the fungus was isolated from stumps throughout the stand but tree mortality was confined to shallow-rooted trees in areas with poor surface drainage. In the jack pine stand, which was planted on a blow-sand area, tree mortality occurred on areas where the root systems had not managed to reach water-holding soil layers and were predisposed to drought injury.

It is believed that the solution to the problem of *Fomes* root rot control is to be found in a better understanding of the relationships existing between parasite, host, and environment. This knowledge will permit a proper choice of tree species for a site and the development of methods of management that will strengthen the disease resistance of the host.

To study the susceptibility of different tree species to infection at an early stage of their life, two experiments have been established at St. Williams. In the first experiment, four tree species are being tested by replanting a cut-over jack pine stand that had been severely diseased. In a second experiment, artificial inoculation of the area with *Fomes*-infected red pine stumps was carried out. This experiment was laid out on a cultivated area free of tree roots, where the trees were planted in ten crosses, each containing four tree species, with the inoculum being placed beneath the center of each cross. It is hoped in this way to obtain valuable information on the choice of tree species for use in replanting infected plantations.

It may be expected that an accumulation of disease-causing micro-organisms will take place during the growth of the first plantation crop; a development that may seriously affect the nature of the disease problems encountered when harvested plantations are replanted to a second crop. However, since these studies of plantation diseases have been initiated early in the development of reforestation in Ontario, it is believed that they will provide substantial assistance to the silviculturist in his efforts to obtain optimal economic production. Many of the disease problems present in forest plantations have arisen as a direct result of man's never-ending efforts to manipulate and control the processes of Nature. Therefore, because these created problems probably are easier to solve, control of plantation diseases may be easier to obtain than the control of other types of forest tree diseases.